SEISMIC HAZARD EVALUATION OF THE BALDWIN PARK 7.5-MINUTE QUADRANGLE, LOS ANGELES COUNTY, CALIFORNIA

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STATE OF CALIFORNIA
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SECRETARY FOR RESOURCES

DEPARTMENT OF CONSERVATION
DARRYL YOUNG
DIRECTOR

DIVISION OF MINES AND GEOLOGY
JAMES F. DAVIS, *STATE GEOLOGIST*

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PREFACE

With the increasing public concern about the potential for destructive earthquakes in northern and southern California, the State Legislature passed the Seismic Hazards Mapping Act in 1990. The purpose of the Act is to protect the public from the effects of strong ground shaking, liquefaction, landslides or other ground failure, and other hazards caused by earthquakes. The program and actions mandated by the Seismic Hazards Mapping Act closely resemble those of the Alquist-Priolo Earthquake Fault Zoning Act (which addresses only surface fault-rupture hazards) and are outlined below:

1. **The State Geologist** is required to delineate the various "seismic hazard zones."

2. **Cities and Counties**, or other local permitting authorities, must regulate certain development "projects" within the zones. They must withhold the development permits for a site within a zone until the geologic and soil conditions of the project site are investigated and appropriate mitigation measures, if any, are incorporated into development plans.

3. **The State Mining and Geology Board (SMGB)** provides additional regulations, policies, and criteria to guide cities and counties in their implementation of the law. The SMGB also provides criteria for preparation of the Seismic Hazard Zone Maps (Web site http://www.consrv.ca.gov/dmg/shezp/zoneguid/) and for evaluating and mitigating seismic hazards.

4. **Sellers (and their agents)** of real property within a mapped hazard zone must disclose at the time of sale that the property lies within such a zone.

As stated above, the Act directs the State Geologist, through the Division of Mines and Geology (DMG) to delineate seismic hazard zones. Delineation of seismic hazard zones is conducted under criteria established by the Seismic Hazards Mapping Act Advisory Committee and its Working Groups and adopted by the California SMGB.

The Official Seismic Hazard Zone Maps, released by DMG, which depict zones of required investigation for liquefaction and/or earthquake-induced landslides, are available from:

> BPS Reprographic Services
> 149 Second Street
> San Francisco, California 94105
> (415) 512-6550

Seismic Hazard Evaluation Reports, released as Open-File Reports (OFR), summarize the development of the hazard zone map for each area and contain background documentation for

use by site investigators and local government reviewers. These Open-File Reports are available for reference at DMG offices in Sacramento, San Francisco, and Los Angeles. Copies of the reports may be purchased at the Sacramento, Los Angeles, and San Francisco offices. In addition, the Sacramento office offers prepaid mail order sales for all DMG OFRs. **NOTE: The Open-File Reports are not available through BPS Reprographic Services.**

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Seismic Hazard Evaluation Reports and additional information on seismic hazard zone mapping in California are available on the Division of Mines and Geology's Internet homepage:
http://www.consrv.ca.gov/dmg/shezp/

INTRODUCTION

The Seismic Hazards Mapping Act (the Act) of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, Division of Mines and Geology (DMG) to delineate seismic hazard zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use the seismic hazard zone maps in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within the hazard zones. Evaluation and mitigation of seismic hazards are to be conducted under guidelines established by the California State Mining and Geology Board (1997; also available on the Internet at http://www.consrv.ca.gov/dmg/pubs/sp/117/).

The Act also directs SMGB to appoint and consult with the Seismic Hazards Mapping Act Advisory Committee (SHMAAC) in developing criteria for the preparation of the seismic hazard zone maps. SHMAAC consists of geologists, seismologists, civil and structural engineers, representatives of city and county governments, the state insurance commissioner and the insurance industry. In 1991 SMGB adopted initial criteria for delineating seismic hazard zones to promote uniform and effective statewide implementation of the Act. These initial criteria provide detailed standards for mapping regional liquefaction hazards. They also directed DMG to develop a set of probabilistic seismic maps for California and to research methods that might be appropriate for mapping earthquake-induced landslide hazards.

In 1996, working groups established by SHMAAC reviewed the prototype maps and the techniques used to create them. The reviews resulted in recommendations that the 1) process for zoning liquefaction hazards remain unchanged and that 2) earthquake-induced landslide zones be delineated using a modified Newmark analysis.

This Seismic Hazard Evaluation Report summarizes the development of the hazard zone map for each area. The process of zoning for liquefaction uses a combination of Quaternary geologic mapping, historic high-water-table information, and subsurface geotechnical data. The process for zoning earthquake-induced landslides incorporates earthquake loading, existing landslide features, slope gradient, rock strength, and geologic structure. Probabilistic seismic hazard maps, which are the underpinning for delineating seismic hazard zones, have been prepared for peak ground acceleration, mode magnitude, and mode distance with a 10% probability of exceedance in 50 years (Petersen and others, 1996) in accordance with the mapping criteria.

This evaluation report summarizes seismic hazard zone mapping for potentially liquefiable soils and earthquake-induced landslides in the Baldwin Park 7.5-Minute Quadrangle (scale 1:24,000).

SECTION 1
LIQUEFACTION EVALUATION REPORT

Liquefaction Zones in the Baldwin Park
7.5-Minute Quadrangle,
Los Angeles County, California

By
Ralph C. Loyd

California Department of Conservation
Division of Mines and Geology

PURPOSE

The Seismic Hazards Mapping Act (the Act) of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, Division of Mines and Geology (DMG) to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use the seismic zone maps in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within the hazard zones. Evaluation and mitigation of seismic hazards are to be conducted under guidelines established by the California State Mining and Geology Board (1997; also available on the Internet at http://www.consrv.ca.gov/pubs/sp/117/).

This evaluation report summarizes seismic hazard zone mapping for potentially liquefiable soils in the Baldwin Park 7.5-minute Quadrangle (scale 1:24,000). This section and Section 2 addressing earthquake-induced landslides, are part of a series that will summarize development of similar hazard zone maps in the state (Smith, 1996). Additional information on seismic hazards zone mapping in California can be accessed on DMG's Internet homepage: http://www.consrv.ca.gov/dmg/shezp/

BACKGROUND

Liquefaction-induced ground failure has historically been a major cause of earthquake damage in southern California. During the 1971 San Fernando and 1994 Northridge earthquakes, significant damage to roads, utility pipelines, buildings, and other structures in the Los Angeles area was caused by liquefaction-induced ground displacement.

Localities most susceptible to liquefaction-induced damage are underlain by loose, water-saturated granular sediments within 40 feet of the ground surface. These geological and ground-water conditions exist in parts of southern California, most notably in some densely populated valley regions and alluviated floodplains. In addition, the opportunity for strong earthquake ground shaking is high because of the many nearby active faults. The combination of these factors constitutes a significant seismic hazard in the southern California region, including the densely populated area encompassed by the Baldwin Park 7.5-minute Quadrangle.

SCOPE AND LIMITATIONS

Evaluation for potentially liquefiable soils is generally confined to areas covered by Quaternary sedimentary deposits. Such areas consist mainly of alluviated valleys, floodplains, and canyon regions. The evaluation is based on earthquake ground shaking, surface and subsurface lithology, geotechnical soil properties, and ground-water depth data, most of which are gathered from a variety of sources. The quality of the data used varies. Although selection of data used in this evaluation was rigorous, the state of California and the Department of Conservation make no representations or warranties regarding the accuracy of the data obtained from outside sources.

Liquefaction zone maps are intended to prompt more detailed, site-specific geotechnical investigations as required by the Act. As such, liquefaction zone maps identify areas where the potential for liquefaction is relatively high. They do not predict the amount or direction of liquefaction-related ground displacements, or the amount of damage to facilities that may result from liquefaction. Factors that control liquefaction-induced ground failure are the extent, depth and thickness of liquefiable sediments, depth to ground water, rate of drainage, slope gradient, proximity to free-face conditions, and intensity and duration of ground shaking. These factors must be evaluated on a site-specific basis to determine the potential for ground failure at any given project site.

Information developed in the study is presented in two parts: physiographic, geologic, and hydrologic conditions in PART I, and liquefaction potential, opportunity, susceptibility, and zoning evaluations in PART II.

PART I

STUDY AREA LOCATION AND PHYSIOGRAPHY

The Baldwin Park Quadrangle covers an area of about 62 square miles in eastern Los Angeles County. The study area lies in densely populated central San Gabriel Valley and includes parts of the cities of Azusa, Baldwin Park, Covina, Duarte, El Monte, Glendora, Industry, Irwindale, La Puente, Monrovia, Walnut, West Covina, as well as unincorporated areas of Los Angles County. Major transportation routes traversing the Baldwin Park Quadrangle include the San Bernardino Freeway (I-10), the Pomona Freeway (State Highway 60), the San Gabriel River Freeway (I-605) and the Foothill Freeway (I-210).

The San Gabriel Valley is a sediment-filled, east-trending structural trough situated along the southern flank of the San Gabriel Mountains. The San Gabriel Mountains are a major component of the Transverse Ranges geomorphic province of California and are comprised largely of plutonic and metamorphic rocks. In the Baldwin Park Quadrangle, the southern boundary of San Gabriel Valley is defined by the Puente Hills and San Jose Hills, which are comprised of Tertiary marine and nonmarine sedimentary rocks.

GEOLOGIC CONDITIONS

Surface Geology

Quaternary geologic units exposed in the Baldwin Park Quadrangle were mapped in detail by McCalpin (unpublished) and Tan (1997). Their maps are based on stratigraphic, geomorphic, and pedologic criteria - namely relative stratigraphic position, environment of deposition, relative degree of erosion, soil type, soil development, and texture (grain size). Both maps were employed in the evaluation of liquefaction susceptibility of the quadrangle.

Map unit nomenclature applied on the accompanying geologic map (Plate 1.1) follows the format developed by the Southern California Areal Mapping Project (SCAMP: Morton and Kennedy, 1989). Plate 1.1 shows that most of the study area is covered by valley alluvial sediments of Quaternary age. In the northern two-thirds of the quadrangle, these deposits consist of varying amounts of sand, gravel, and silt layers that are incorporated within large, composite alluvial fans associated with the San Gabriel River, Walnut Creek and Oak Creek, and the Big Dalton and Little Dalton washes. South and west of the San Jose Hills, floodplain deposits associated with San Jose Creek constitute most of the alluvial deposits. The general mineralogy of the Quaternary sediments deposited north of the San Jose Hills reflects the composition of Pre-Tertiary crystalline bedrock units exposed in the San Gabriel Mountains to the north, whereas the alluvial sediments deposited within the San Jose Creek stream valley reflect Tertiary units exposed in the San Jose Hills and Puente Hills.

Subsurface Geology and Geotechnical Characteristics

Over 120 borehole logs available within the study area were examined and related to the mapped surface geology. Subsurface data used for this study include borehole logs collected from the California Department of Transportation (CalTrans), the California Department of Water Resources, the Regional Water Quality Control Board, Los Angeles County Flood Control files by U.S. Geological Survey staff, DMG files of seismic reports for hospital and school sites, and a database of shear wave velocity measurements originally compiled by Walter Silva (Wills and Silva, 1998). Locations and geotechnical data from borehole logs were entered into the DMG Geographic Information System (GIS) database. Locations of all exploratory boreholes considered in this investigation are shown on Plate 1.2.

Construction of cross sections using data reported on the borehole logs enabled staff to relate soil engineering properties to various depositonal units, to correlate soil types from one borehole to another, and to extrapolate geotechnical data into outlying areas containing similar soils.

GROUND-WATER CONDITIONS

Liquefaction hazard mapping focuses on areas historically characterized by ground water depths of 40 feet or less. Accordingly, a ground-water evaluation was performed in the Baldwin Park Quadrangle to determine the presence and extent of historically shallow ground water. Data required to conduct the evaluation were obtained from technical publications, geotechnical boreholes, and water-well logs dating back to the turn-of-the-century, namely 1904 ground-water contour maps (Mendenhall, 1908), 1944 ground-water contour maps (California Department of Water Resources, 1966), and ground-water level measurements reported in compiled 1960-1997 geotechnical borehole logs.

The evaluation showed that the 1904 and 1944 ground-water levels within the Baldwin Park Quadrangle were quite similar. Both sets of maps demonstrate that shallow-water conditions (less than 40 feet depth) exist over a large area in the southwestern part of the quadrangle (near the Whittier Narrows) and along the southern margin within the San Jose Creek stream valley.

Where records were examined, ground water is also relatively shallow in restricted drainages within the Puente and San Jose Hills. In general, it appears that relatively shallow and impermeable bedrock underlying the stream canyon sediments results in a shallow water table. These sediments can also remain saturated for long periods of time during wet seasons.

PART II

EVALUATING LIQUEFACTION POTENTIAL

Liquefaction occurs in water-saturated sediments during moderate to great earthquakes. Liquefied sediments are characterized by a loss of strength and may fail, causing damage to buildings, bridges, and other such structures. A number of methods for mapping liquefaction

hazard have been proposed; Youd (1991) highlights the principal developments and notes some of the widely used criteria. Youd and Perkins (1978) demonstrate the use of geologic criteria as a qualitative characterization of susceptibility units, and introduced the mapping technique of combining a liquefaction susceptibility map and a liquefaction opportunity map to produce liquefaction potential. Liquefaction susceptibility is a function of the capacity of sediments to resist liquefaction and liquefaction opportunity is a function of the seismic ground shaking intensity. The application of the Seed Simplified Procedure (Seed and Idriss, 1971) for evaluating liquefaction potential allows a quantitative characterization of susceptibility of geologic units. Tinsley and others (1985) applied a combination of the techniques used by Seed and others (1983) and Youd and Perkins (1978) for mapping liquefaction hazards in the Los Angeles region. The method applied in this study for evaluating liquefaction potential is similar to that of Tinsley and others (1985), combining geotechnical data analyses, and geologic and hydrologic mapping, but follows criteria adopted by the California State Mining and Geology Board (in press).

LIQUEFACTION OPPORTUNITY

According to the criteria adopted by the California State Mining and Geology Board (1993), liquefaction opportunity is a measure, expressed in probabilistic terms, of the potential for ground shaking strong enough to generate liquefaction. Analyses of in-situ liquefaction resistance require assessment of liquefaction opportunity. The minimum level of seismic excitation to be used for such purposes is the level of peak ground acceleration (PGA) with a 10% probability of exceedance over a 50-year period. The earthquake magnitude is the magnitude that contributes most to the acceleration.

For the Baldwin Park Quadrangle, peak accelerations of 0.47 g to 0.56 g resulting from an earthquake of magnitude 6.8 to 7.0 were used for liquefaction analyses. The PGA and magnitude values were derived from maps prepared by Petersen and others (1996) and Cramer and Petersen (1996), respectively. See the ground motion portion (Section 3) of this report for further details.

LIQUEFACTION SUSCEPTIBILITY

Liquefaction susceptibility reflects the relative resistance of soils to loss of strength when subjected to ground shaking. Primarily, physical properties and conditions of soil such as sediment grain-size distribution, compaction, cementation, saturation, and depth govern the degree of resistance. Soils that lack resistance (susceptible soils) are typically saturated, loose sandy sediments. Soils resistant to liquefaction include all soil types that are dry or sufficiently dense. Cohesive soils are generally not considered susceptible to liquefaction.

 DMG's map inventory of areas containing soils susceptible to liquefaction begins with evaluation of geologic maps, cross-sections, geotechnical test data, geomorphology, and ground-water hydrology. Soil-property and soil-condition factors such as type, age, texture, color, and consistency, along with historic depths to ground water are used to identify, characterize, and

correlate susceptible soils.   Because Quaternary geologic mapping is based on similar soil observations, findings can be related to the map units. DMG's qualitative susceptible soil inventory is summarized on Table 1.1.

As discussed in the Geologic Conditions section of this report, young Quaternary geologic units, which cover most of the Baldwin Park Quadrangle (Plate 1.1; Table 1.2), are dominated by loose to moderately dense sandy sediments. Where saturated within 40 feet of the ground surface (Plate 1.2), these deposits are judged to be susceptible to liquefaction. Such conditions prevail over an area covering about 19 square miles, or almost one-third of the Baldwin Park Quadrangle.

Map Unit	Age	Environment of Deposition	Primary Textures	General Consistency	Susceptible to Liquefaction?*
Qw	latest Holocene	active stream channels	sand, gravel, cobbles	very loose to loose	yes
Qf	latest Holocene	active alluvial fan deposits	sand, silt gravel	very loose to loose	yes
Qa	latest Holocene	active alluvial basin deposits	sand, silt, clay	very loose to loose	yes
Qyf1-4	Holocene to latest Pleistocene	younger alluvial fan deposits	gravel, sand, silt	loose to moderately dense	yes
Qya1-4	Holocene to latest Pleistocene	Younger alluvial basin deposits	sand, silt, clay	loose to moderately dense	yes
Qof	late Pleistocene	older alluvial fan deposits	sand, gravel, silt, clay	dense to very dense	not likely
Qoa	late Pleistocene	older alluvial basin deposits	sand, silt, clay	dense to very dense	not likely
Qvoa	Pleistocene	very old alluvial basin deposits	gravel, sand, silt, clay	dense to very dense	not likely

* When saturated.

Table 1.1.   General geotechnical characteristics and liquefaction susceptibility of Quaternary sedimentary deposits in the Baldwin Park Quadrangle.

Quantitative Liquefaction Analysis

DMG performs quantitative analysis of geotechnical data to evaluate liquefaction potential using the Seed Simplified Procedure (Seed and Idriss, 1971; Seed and others, 1983; Seed and Harder, 1990; Youd and Idriss, 1997). This procedure calculates soil resistance to liquefaction, expressed in terms of cyclic resistance ratio (CRR) based on standard penetration test (SPT)

results, ground-water level, soil density, moisture content, soil type, and sample depth. CRR values are then compared to calculated earthquake-generated shear stresses, expressed in terms of cyclic stress ratio (CSR). The factor of safety (FS) relative to liquefaction is: FS=CRR/CSR. FS, therefore, is a quantitative measure of liquefaction potential. Generally, a factor of safety of 1.0 or less, where CSR equals or exceeds CRR, indicates the presence of potentially liquefiable soil. DMG uses FS, as well as other considerations such as slope, free face conditions, and thickness and depth of potentially liquefiable soil, to construct liquefaction potential maps, which then directly translate to Zones of Required Investigation.

Of the 122 geotechnical borehole logs reviewed in this study (Plate 1.2), 69 include blow-count data from SPT's or from penetration tests that allow reasonable blow count translations to SPT-equivalent values. Non-SPT values, such as those resulting from the use of 2-inch or 2 1/2-inch inside diameter ring samplers, were translated to SPT-equivalent values if reasonable factors could be used in conversion calculations. Few borehole logs, however, include all of the information (soil density, moisture content, sieve analysis, etc) required for an ideal Seed Simplified Analysis. For boreholes having acceptable penetration tests, liquefaction analysis is performed using either logged density, moisture, and sieve test values or average test values of similar materials.

LIQUEFACTION ZONES

Criteria for Zoning

The areas underlain by late Quaternary geologic units were included in liquefaction zones using the criteria developed by the Seismic Hazards Mapping Act Advisory Committee and adopted by the California State Mining and Geology Board (in press). Under those criteria, liquefaction zones are areas meeting one or more of the following:

1. Areas known to have experienced liquefaction during historic earthquakes.

2. All areas of uncompacted fills containing liquefaction susceptible material that   are saturated, nearly saturated, or may be expected to become saturated.

3. Areas where sufficient existing geotechnical data and analyses indicate that the   soils are potentially liquefiable.

4. Areas where existing geotechnical data are insufficient**.**

In areas of limited or no geotechnical data, susceptibility zones may be identified by geologic criteria as follows:

a) Areas containing soil deposits of late Holocene age (current river channels and their historic floodplains, marshes and estuaries), where the M7.5-weighted peak acceleration that has a

10% probability of being exceeded in 50 years is greater than or equal to 0.10 g and the water table is less than 40 feet below the ground surface; or

b) Areas containing soil deposits of Holocene age (less than 11,000 years), where the M7.5-weighted peak acceleration that has a 10% probability of being exceeded in 50 years is greater than or equal to 0.20 g and the historic high water table is less than or equal to 30 feet below the ground surface; or

c) Areas containing soil deposits of latest Pleistocene age (between 11,000 years and 15,000 years), where the M7.5-weighted peak acceleration that has a 10% probability of being exceeded in 50 years is greater than or equal to 0.30 g and the historic high water table is less than or equal to 20 feet below the ground surface.

Application of SMGB criteria for liquefaction zoning in the Baldwin Park Quadrangle is summarized below.

Areas of Past Liquefaction

No areas of documented historic liquefaction in the Baldwin Park Quadrangle are known. Areas showing evidence of paleoseismic liquefaction have not been reported.

Artificial Fills

Artificial fill sites in the Baldwin Park Quadrangle include water basin dams and river levees. Although these fills were certainly properly engineered, seismic hazard zoning for liquefaction at these localities is governed by the liquefaction susceptibility of natural soils underlying the fill sites.

Areas with Existing Geotechnical Data

Sufficient geologic and geotechnical data exist for DMG to adequately evaluate liquefaction potential of alluvial sediments throughout the Baldwin Park Quadrangle. DMG's liquefaction susceptible soil inventory and quantitative analyses of geotechnical data in the Baldwin Park indicate that all Holocene and modern soils saturated within 40 feet of the ground surface are potentially liquefiable. These conditions are present over a 19-square-mile area, almost one-third of the quadrangle. Accordingly, DMG delineates this area as a Zone of Required Investigation.

Areas without Existing Geotechnical Data

 Some stream drainage and alluviated low land areas within the San Jose and Puente Hills are zoned on the basis of SMGB criteria for areas where geotechnical data are lacking or insufficient. Most of these areas were placed within Zones of Required Investigations because such soils generally reflect conditions named in criteria item 4a.

ACKNOWLEDGMENTS

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SECTION 2
EARTHQUAKE-INDUCED LANDSLIDE EVALUATION REPORT

Earthquake-Induced Landslide Zones
in the Baldwin Park 7.5-Minute Quadrangle,
Los Angeles County, California

By

Florante G. Perez, Timothy P. McCrink, Siang S. Tan, and Rick I. Wilson

California Department of Conservation
Division of Mines and Geology

PURPOSE

The Seismic Hazards Mapping Act (the Act) of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, Division of Mines and Geology (DMG) to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use the seismic hazard zone maps in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within the hazard zones. Evaluation and mitigation of seismic hazards are to be conducted under guidelines established by the California State Mining and Geology Board (1997; also available on the Internet at http://www.consrv.ca.gov/pubs/sp/117/).

This evaluation report summarizes seismic hazard zone mapping for earthquake-induced landslides in the Baldwin Park 7.5-minute Quadrangle (scale 1:24,000). This section and Section 1 addressing liquefaction, are part of a series that will summarize development of similar hazard zone maps in the state (Smith, 1996). Additional information on seismic hazard zone mapping in California can be accessed on DMG's Internet homepage: http://www.consrv.ca.gov/dmg/shezp/

BACKGROUND

Landslides triggered by earthquakes have historically been a major cause of earthquake damage. Landslides triggered by the 1971 San Fernando, 1989 Loma Prieta, and 1994 Northridge earthquakes were responsible for destroying or damaging numerous homes and other structures, blocking major transportation corridors, and damaging various types of life-line infrastructure. Typically, areas most susceptible to earthquake-induced landslides are on steep slopes and on or adjacent to existing landslide deposits, especially if the earth materials in these areas are composed of loose colluvial soils, or poorly cemented or highly fractured rock. These geologic and terrain conditions exist in many parts of southern California, most notably in hilly areas already developed or currently undergoing development. In addition, the opportunity for strong earthquake ground shaking is high because of the many nearby active faults. The combination of these factors constitutes a significant seismic hazard in the southern California region, which includes the Baldwin Park Quadrangle.

SCOPE AND LIMITATIONS

The methodology used to make this map is based on earthquake ground-shaking estimates, geologic material-strength characteristics and slope gradient. These data are gathered primarily from a variety of outside sources; thus the quality of the data is variable. Although the selection of data used in this evaluation was rigorous, the state of California and the Department of Conservation make no representations or warranties regarding the accuracy of the data gathered from outside sources.

Earthquake-induced landslide zone maps are intended to be used to prompt more detailed, site-specific geotechnical investigations as required by the Act. As such, these zone maps identify areas where the potential for earthquake-induced landslides is relatively high. Earthquake-generated ground failures that are not addressed by this map include those associated with ridge-top spreading and shattered ridges. No attempt has been made to map potential run-out areas of triggered landslides. It is possible that such run-out areas may extend beyond the zone boundaries. The potential for ground failure resulting from liquefaction-induced lateral spreading of alluvial materials, considered by some to be a form of landsliding, is not specifically addressed by the earthquake-induced landslide zone or this report. See Section 1, Liquefaction Evaluation Report for the Baldwin Park Quadrangle, for more information on the delineation of liquefaction zones.

Information developed in the study is presented in two parts: physiographic, and geologic conditions in PART I, and ground shaking opportunity, landslide hazard potential and zoning evaluations in PART II.

PART I

STUDY AREA LOCATION AND PHYSIOGRAPHY

The Baldwin Park Quadrangle covers an area of about 62 square miles in eastern Los Angeles County. The study area lies in densely populated central San Gabriel Valley and includes parts of the cities of Azuza, Baldwin Park, Covina, Duarte, El Monte, Glendora, Industry, Irwindale, La Puente, Monrovia, Walnut, West Covina, as well as unincorporated areas of Los Angles County. Major transportation routes traversing the Baldwin Park Quadrangle include the San Bernardino Freeway (I-10), the Pomona Freeway (State Highway 60), the San Gabriel River Freeway (I-605) and the Foothill Freeway (I-210).

The San Gabriel Valley is a sediment-filled, east-trending structural trough situated along the southern flank of the San Gabriel Mountains. The San Gabriel Mountains are a major component of the Transverse Ranges geomorphic province of California and are comprised largely of plutonic and metamorphic rocks. In the Baldwin Park Quadrangle, the southern boundary of San Gabriel Valley is defined by the Puente Hills and San Jose Hills, which are comprised of Tertiary marine and nonmarine sedimentary rocks.

GEOLOGIC CONDITIONS

Surface and Bedrock Geology

For the Baldwin Park Quadrangle, a geologic map was compiled and digitized by the Southern California Mapping Project (SCAMP: Morton and Kennedy, 1989) from original mapping by Tan (1997). The digital geologic map obtained from SCAMP was modified to reflect the most recent mapping in the area. In the field, observations were made of exposures, aspects of weathering, and general surface expression of the geologic units. In addition, the relation of the various geologic units to development and abundance of landslides was noted.

The oldest geologic unit mapped in the Baldwin Park Quadrangle is the middle-upper Miocene Puente Formation consisting of a very thick sequence of marine sandstone, siltstone, shale, and pebble conglomerate. It is extensively exposed in the southeastern portion of the quadrangle with smaller outcrops in the southwest corner. The Puente Formation is subdivided into four members. The lowest member, the La Vida Member (Tpl), consists of laminated to platy siltstone with interbedded pebbly sandstone (Tplc) and local limestone and tuff beds. The La Vida Member grades upwards into the Soquel Member (Tpsq), which consists of massive to, locally, thick-bedded sandstone with interbedded clayey siltstone and pebble-cobble conglomerate (Tpsqc). The Yorba Member (Tpy) has a gradational contact with the Soquel Member and is made up of interbedded sandy and diatomaceous siltstone containing thin beds of limestone and thin-bedded to massive sandstone. The uppermost member, the Sycamore Canyon Member (Tpsc), consists of interlayered micaceous siltstone and coarse-grained sandstone with interbedded conglomerate (Tpscc).

Overlying the Puente Formation is the Pliocene Fernando Formation (Tf) that consists of repetitiously interbedded fine to coarse clastic marine strata that is divided into lower (Tfl) and upper (Tfu) members on the basis of an extensive erosional unconformity and lithologic variations (Yerkes and others, 1965).   In the vicinity of Hacienda Boulevard, the lower member forms subdued rounded slopes consisting of sandy micaceous siltstone and very fine- to medium-grained micaceous friable sandstone. It is also exposed in the northwest end of the Little Puente Hills along the nose of an anticline where it is interbedded with pebble-cobble conglomerate (Tflc) that consists of subrounded to well-rounded light-colored crystalline-rock clasts. The upper member consists of massive and friable silty and pebbly sandstone with interbedded siltstone and pebble conglomerate (Tfuc). It has a very limited exposure in the southeast corner of the quadrangle and along the nose of the Little Puente Hill anticline.

Quaternary deposits cover the floor and margins of San Gabriel Valley, including stream channels, alluvial fans, and flood plains. They are composed of active channel wash (Qw1a, Qw1ag, Qw1g, Qwa, Qwag), younger alluvial fan deposits (Qyfa, Qyfag, Qyfc, Qyfcs, Qyfg, Qyfs, Qyfsc), and older alluvial fan and terrace deposits (Qof1a, Qof2a, Qof2s, Qof3s, Qofs). Landslides (Qls, Qls?) are widespread in the southeastern and southwestern portions of the quadrangle. A more detailed discussion of the Quaternary deposits in the Baldwin Park Quadrangle can be found in Section 1.

Geologic Material Strength

To evaluate the stability of geologic materials under earthquake conditions, they must first be ranked on the basis of their overall shear strength. Shear strength data for the rock units identified on the geologic map were obtained from geotechnical reports prepared by consultants and on file with the local government permitting departments, from the Corporate Library of Leighton and Associates, Inc., the City of West Covina, and the Los Angeles County Department of Public Works (see Appendix A). The locations of rock and soil samples taken for shear testing are shown on Plate 2.1.

Shear strength data gathered from the above sources were compiled for each mapped geologic unit, and subdivided for fine-grained and coarse-grained lithologies, if appropriate. Geologic units were grouped on the basis of average angle of internal friction (average $\mathbf{f}$) and lithologic character. Geologic formations that had little or no shear test information were added to existing groups on the basis of lithologic and stratigraphic similarities.

To subdivide mapped geologic formations that have both fine-grained and coarse-grained lithologies, we assumed that where stratigraphic bedding dips into a slope (favorable bedding) the coarse-grained material strength dominates, and where bedding dips out of a slope (adverse bedding) the fine-grained material strength dominates. We then used structural information from the geologic map (see "Structural Geology") and terrain data in the form of slope gradient and aspect, to identify areas with a high potential for containing adverse bedding conditions. These areas, located on the map, were then used to modify the geologic material-strength map to reflect the anticipated lower shear strength for the fine-grained materials.

The results of the grouping of geologic materials in the Baldwin Park Quadrangle are in Tables 2.1 and 2.2.

BALDWIN PARK QUADRANGLE
SHEAR STRENGTH GROUPS STATISTICS

	Formation Name	Number of Tests	Mean Phi Value	Group Phi Mean/Median (degrees)	Group C Mean/Median (psf)	No Data Similar Lithology	Phi Values Used in Stability Analysis
Group 1	Tpy(crse)	3	35.6	35.6/35.0	433/280		35
Group 2	Tpsq (crse) Tpsc(crse)	1 9	33.0 31.5	31.7/32.5	913/890	Tpsqc, Tpscc Tfl, Tflc	32
Group 3	Tpsq(fine) Tpsc(fine) Qof	1 14 16	30.0 29.8 27.9	28.9/28.0	106/102	Qof1a,Qof2a,Qof2s Qof3s,Qofs,Tfu,Tfuc Tpl(crse), Tpls	29
Group 4	Tpy(fine) Tpl (fine) Qyf	12 7 29	25.6 24.5 25.8	25.6/25.0	565/500	Qw1a,Qw1ag,Qw1g Qwa,Qwag,Qyfa Qyfag,Qyfc,Qyfcs Qyfg,Qyfs,Qyfsc	26
Group 5	Qls					QlsD, QlsP	*12*

Table 2.1. Summary of the Shear Strength Statistics for the Baldwin Park Quadrangle.

BALDWIN PARK QUADRANGLE
SHEAR STRENGTH GROUPS

Group 1	Group 2	Group 3	Group 4	Group 5
Tpy(crse)	Tpsq(crse)	Tpsq(fine)	Tpy(fine)	QlsD
	Tpsc(crse)	Tpsc(fine)	Tpl (fine)	QlsP
	Tpsqc,Tpscc	Tpl(crse)	Qwla,Qwlag	
	Tfl,Tflc	Tpls,Tfu,Tfuc	Qwlg,Qwa,Qwag	
		Qofla,Qof2a	Qyfa,Qyfag,Qyfc	
		Qof2s,Qof3s	Qyfcs,Qyfg,Qyfs	
		Qofs	Qyfsc	

Table 2.2.   Summary of the Shear Strength Groups for the Baldwin Park Quadrangle.

Structural Geology

Accompanying the digital geologic map were digital files of associated geologic structural data, including bedding and foliation attitudes (strike and dip) and fold axes. We used the structural geologic information provided with the digital geologic map (SCAMP) and from Tan (1997) to categorize areas of common stratigraphic dip direction and magnitude, similar to the method presented by Brabb (1983). The dip direction category was compared to the slope aspect (direction) category and, if the same, the dip magnitude and slope gradient categories were compared. If the dip magnitude category was less than or equal to the slope gradient category, and the bedding dip was greater than 25% (4:1 slope), the area was marked as a potential adverse bedding area. This information was then used to subdivide mapped geologic units into areas where fine-grained and coarse-grained strengths would be used.

Folds are the dominant structural features of San Jose Hills, consisting of two anticlines and an intervening syncline that all trend generally eastward. The crest of the San Jose anticline more or less follows the principal drainage divide but farther west it curves gently northward where the nose plunges about 30 degrees westward. The Amar syncline is asymmetric with a steep north limb and a gentler south limb. The Little Puente Hills anticline is symmetrical throughout most of its extent and plunges westward on the western end of the hill.

Numerous faults transect the area, the most notable are the north-northeast-trending Walnut Creek fault, the San Jose fault, the Little Puente Hills fault, and the Whittier Heights fault.

Landslide Inventory

The evaluation of earthquake-induced landsliding requires an up-to-date and complete analysis of previously mapped landslides. DMG geologists compiled the existing landslides in the Baldwin Park Quadrangle from published landslide hazard maps by Tan (1988). Then by combining analysis of aerial photos and interpretation of landforms with field observations, all landslides compiled on the map were verified, re-mapped, or deleted during the preparation of the landslide

inventory map. The most landslide-prone bedrock units in the quadrangle are the Yorba and La Vida members of the Puente Formation. The most stable are the coarse-grained portions of Yorba Member and the Soquel Member of the Puente Formation. Most of the landslides inventoried are debris slides, block slides, and slumps.

The landslide inventory map was digitized and attributed with information on confidence of interpretation (definite, probable, or questionable) and other properties such as activity, thickness, and associated geologic unit(s). Only those landslides classified in the DMG inventory as definite or probable were incorporated into the hazard-evaluation process. A version of this landslide inventory is included with Plate 2.1.

PART II

EARTHQUAKE-INDUCED LANDSLIDE GROUND SHAKING OPPORTUNITY

Design Strong-Motion Record

The Newmark analysis used in delineating the earthquake-induced landslide zones requires the selection of a design earthquake strong-motion record. For the Baldwin Park Quadrangle, the selection was based on an estimation of probabilistic ground motion parameters for modal magnitude, modal distance, and peak ground acceleration (PGA). The parameters were estimated from maps prepared by DMG for a 10% probability of being exceeded in 50 years (Petersen and others, 1996; Cramer and Petersen, 1996). The parameters used in the record selection are:

Modal Magnitude:	6.8 to 7.0
Modal Distance:	2.6 to 9.4 km
PGA:	0.48 to 0.71g

The strong-motion record selected was the Channel 3 (north 35 degrees east horizontal component) University of Southern California Station #14 recording from the magnitude 6.7 Northridge earthquake (Trifunac and others, 1994). This record had a source-to-recording site distance of 8.5 km and a PGA of 0.59 g. The selected strong-motion record was not scaled or otherwise modified prior to analysis.

Displacement Calculation

To develop a relationship between the yield acceleration (a_y; defined as the horizontal ground acceleration required to cause the factor of safety to equal 1.0) and Newmark displacements, the design strong-motion record was integrated twice for a given a_y to find the corresponding displacement, and the process repeated for a range of a_y (Jibson, 1993). The resulting curve in

Figure 2.1 represents the full spectrum of displacements that can be expected for any combination of geologic material strength and slope angle, as represented by the yield acceleration. We used displacements of 30, 15 and 5 cm as criteria for rating levels of earthquake shaking damage on the basis of the work of Youd (1980), Wilson and Keefer (1983), and the DMG pilot study for earthquake-induced landslides (McCrink and Real, 1996). Applied to the curve in Figure 2.1, these displacements correspond to yield accelerations of 0.076, 0.129 and 0.232 g. Because these yield acceleration values are derived from the design strong-motion record, they represent the ground shaking opportunity thresholds that are significant to the Baldwin Park Quadrangle.
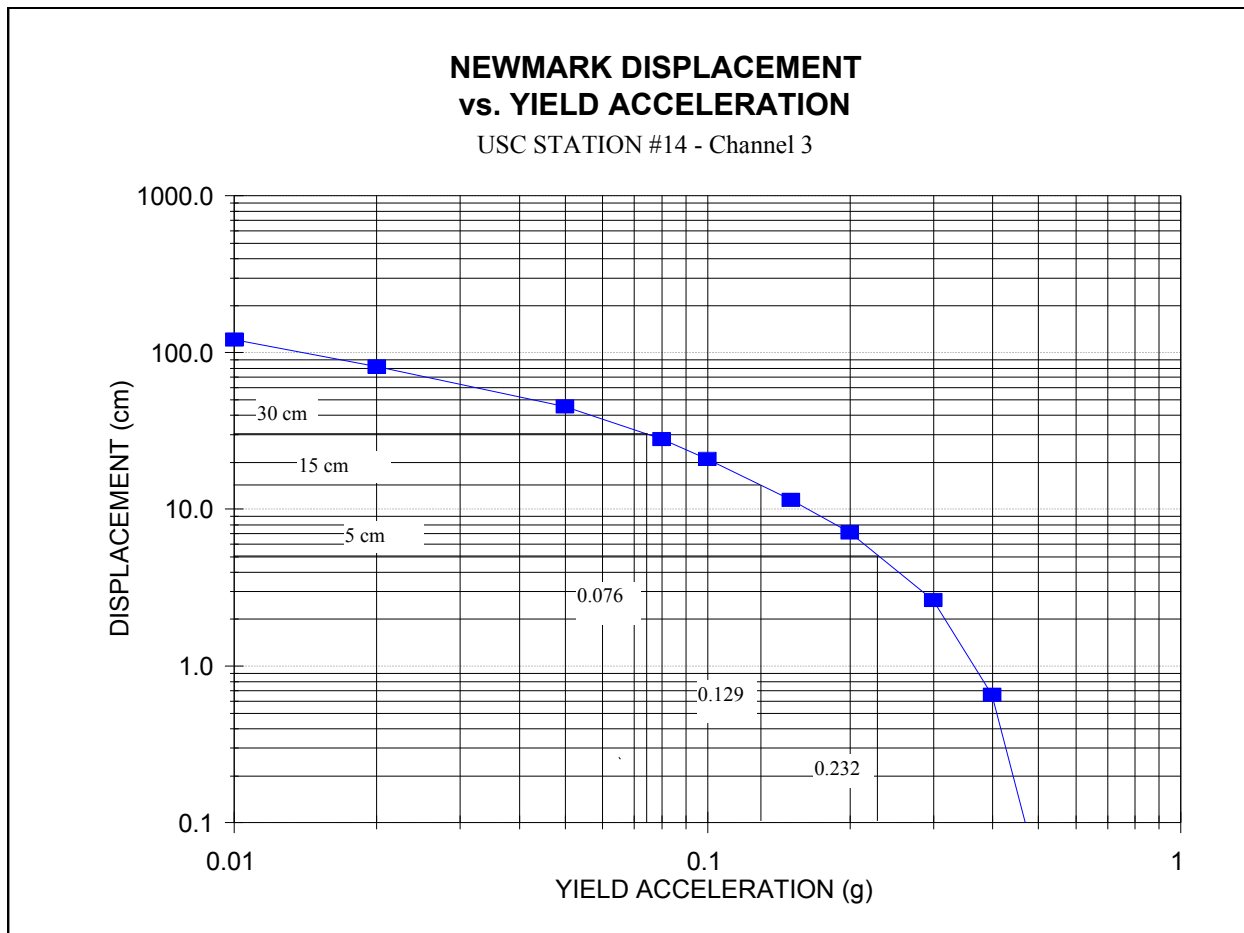

Figure 2.1. Yield acceleration vs. Newmark displacement for the USC Station # 14 Strong-Motion Record From the 17 January 1994 Northridge, California Earthquake.

EARTHQUAKE-INDUCED LANDSLIDE HAZARD POTENTIAL

Terrain Data

The calculation of slope gradient is an essential part of the evaluation of slope stability under earthquake conditions. To calculate slope gradient for the terrain within the Baldwin Park Quadrangle, a Level 2 digital elevation model (DEM) was obtained from the USGS (U.S. Geological Survey, 1993). This DEM, which was prepared from the 7.5-minute quadrangle contours, has a 10-meter horizontal resolution and a 7.5-meter vertical accuracy. Surrounding quadrangle DEMs were merged with the Baldwin Park DEM to avoid the loss of data at the quadrangle edges when the slope calculations were performed. A peak and pit smoothing process was then performed to remove errors in the elevation points.

To update the topographic base map, areas that have undergone large-scale grading as a part of residential development in the hilly portions of the Baldwin Park Quadrangle were identified. Using 1:40,000-scale NAPP photography taken in June 1994, and October 1995, photogrammetric DEMs covering the graded areas were prepared by the U.S. Bureau of Reclamation with ground control obtained by DMG (USGS, 1994; 1995). The photogrammetric DEMs were then merged into the USGS DEM, replacing the areas of out-dated elevation data. Plate 2.1 shows those areas where the topography is updated to 1994-95 grading conditions.

A slope-gradient map was made from the combined DEMs using a third-order, finite difference, center-weighted algorithm (Horn, 1981). This map was used in conjunction with the geologic strength map in preparation of the earthquake-induced landslide hazard potential map.

Stability Analysis

A slope stability analysis was performed for each geologic material strength group at slope increments of one degree. An infinite-slope failure model under unsaturated slope conditions was assumed. A factor of safety was calculated first, followed by the calculation of yield acceleration from Newmark's equation:

$$a_y = (FS - 1)g \sin \alpha$$

where FS is the Factor of Safety, g is the acceleration due to gravity, and α is the direction of movement of the slide mass, in degrees measured from the horizontal, when displacement is initiated (Newmark, 1965). For an infinite slope failure α is the same as the slope angle.

The yield acceleration calculated by Newmark's equation represents the susceptibility to earthquake-induced failure of each geologic material strength group for a range of slope gradients. The acceleration values were compared with the ground shaking opportunity, defined by Figure 2.1, to determine the earthquake-induced landslide hazard potential. Based on the criteria described in Figure 2.1 above, if the calculated yield acceleration was less than 0.076g, expected displacements could be greater than 30 cm, and a HIGH (H on Table 2.3) hazard

potential was assigned. Likewise, if the calculated a_y fell between 0.076 and 0.129g a MODERATE (M on Table 2.3) potential was assigned, between 0.129 and 0.232 a LOW (L on Table 2.3) potential was assigned, and if a_y were greater than 0.232g a VERY LOW (VL on Table 2.3) potential was assigned.

Table 2.3 summarizes the results of the stability analyses. The earthquake-induced landslide hazard potential map was prepared by combining the geologic material-strength map and the slope map according to this table.

BALDWIN PARK QUADRANGLE HAZARD POTENTIAL MATRIX

Geologic Material Group	SLOPE CATEGORY								
	I	II	III	IV	V	VI	VII	VIII	
	0 to 8	9 to 24	25 to 31	32 to 37	38 to 45	46 to 54	55 to 61	>62	Percent
	0 to 4	5 to 13	14 to 17	18 to 20	21 to 24	25 to 28	29 to 31	> 32	Degrees
Group 1	VL	VL	VL	VL	VL	L	M	H	
Group 2	VL	VL	VL	VL	L	M	H	H	
Group 3	VL	VL	VL	L	M	H	H	H	
Group 4	VL	VL	L	M	H	H	H	H	
Group 5	L	H	H	H	H	H	H	H	

Table 2.3. Hazard Potential Matrix for Earthquake-Induced Landslides in the Baldwin Park Quadrangle. Shaded area indicates the hazard potential levels included in the hazard zone.

EARTHQUAKE-INDUCED LANDSLIDE ZONE

Criteria for Zoning

Earthquake-induced landslide zones were delineated using criteria adopted by the California State Mining and Geology Board (in press). Under those criteria, earthquake-induced landslide zones are areas meeting one or more of the following:

1. Areas known to have experienced earthquake-induced slope failure during historic earthquakes.

2. Areas identified as having past landslide movement, including both landslide deposits and source areas.

3. Areas where CDMG's analyses of geologic and geotechnical data indicate that the geologic materials are susceptible to earthquake-induced slope failure.

Existing Landslides

Studies of the types of landslides caused by earthquakes (Keefer, 1984) show that re-activation of the whole mass of deep-seated landslide deposits is rare. However, it has been observed that the steep scarps and toe areas of existing landslides, which formed as a result of previous landslide movement, are particularly susceptible to earthquake-induced slope failure. In addition, because they have been disrupted during landslide movement, landslide deposits are inferred to be weaker than coherent, undisturbed, adjacent source rocks. Finally, we felt that a long duration, San Andreas fault-type earthquake could be capable of initiating renewed movement in existing deep-seated landslide deposits. Therefore, all existing landslides identified in the inventory with a definite or probable confidence of interpretation were included in the hazard zone.

No definitive earthquake-induced landslides were identified in the Baldwin Park Quadrangle.

Geologic and Geotechnical Analysis

On the basis of a DMG pilot study (McCrink and Real, 1996) the earthquake-induced landslide zone includes all areas determined to lie within the High, Moderate and Low levels of hazard potential. Therefore, as shown in Table 2.3, geologic strength group 5 (mapped landslides) is always included in the zone; strength group 4 is in the zone for all slopes greater than 24%; strength group 3 above 31%; strength group 2 above 37%; and strength group 1, the strongest rock types, were zoned for slope gradients above 45%. This results in roughly 5% of the land in the Baldwin Park Quadrangle lying within the hazard zone.

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APPENDIX A
SOURCES OF ROCK STRENGTH DATA

SOURCE	NUMBER OF TESTS SELECTED
Leighton and Associates, Inc. Corporate Library	**38**
City of West Covina	**46**
Los Angeles County Department of Public Works, Material Engineering Division files	**29**
Total number of tests considered to characterize the units in the Baldwin Park Quadrangle	**113**

SECTION 3
GROUND SHAKING EVALUATION REPORT

Potential Ground Shaking in the
Baldwin Park 7.5-Minute Quadrangle,
Los Angeles County, California

By

**Mark D. Petersen, Chris H. Cramer, Geoffrey A. Faneros,
Charles R. Real and Michael S. Reichle**

**California Department of Conservation
Division of Mines and Geology**

PURPOSE

The Seismic Hazards Mapping Act (the Act) of 1990 (Public Resources Code, Chapter 7.8, Division 2) directs the California Department of Conservation, Division of Mines and Geology (DMG) to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. Cities, counties, and state agencies are directed to use the Seismic Hazard Zone Maps in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within the hazard zones. Evaluation and mitigation of seismic hazards are to be conducted under guidelines established by the California State Mining and Geology Board (1997; also available on the Internet at http://www.consrv.ca.gov/dmg/pubs/sp/117/).

This section of the evaluation report summarizes the ground motions used to evaluate liquefaction and earthquake-induced landslide potential for zoning purposes. Included, are ground motion and related maps, a brief overview on how these maps were prepared, precautionary notes concerning their use, and related references. The maps provided herein are presented at a scale of approximately 1:150,000 (scale bar provided on maps), and show the full 7.5- minute quadrangle and portions of the adjacent eight quadrangles. They can be used to assist in the specification of earthquake loading conditions *for the analysis of ground failure*

according to the "Simple Prescribed Parameter Value" method (SPPV) described in the site investigation guidelines (California State Mining and Geology Board, 1997). Alternatively, they can be used as a basis for comparing levels of ground motion determined by other methods with the statewide standard.

This section and Sections 1 and 2, addressing liquefaction and earthquake-induced landslide hazards, constitute a report series that summarizes development of seismic hazard zone maps in the state. Additional information on seismic hazard zone mapping in California can be accessed on DMG's Internet homepage: http://www.consrv.ca.gov/dmg/shezp/

EARTHQUAKE HAZARD MODEL

The estimated ground shaking is derived from the seismogenic sources as published in the statewide probabilistic seismic hazard evaluation released cooperatively by the California Department of Conservation, Division of Mines and Geology, and the U.S. Geological Survey (Petersen and others, 1996). That report documents an extensive 3-year effort to obtain consensus within the scientific community regarding fault parameters that characterize the seismic hazard in California. Fault sources included in the model were evaluated for long-term slip rate, maximum earthquake magnitude, and rupture geometry. These fault parameters, along with historical seismicity, were used to estimate return times of moderate to large earthquakes that contribute to the hazard.

The ground shaking levels are estimated for each of the sources included in the seismic source model using attenuation relations that relate earthquake shaking with magnitude, distance from the earthquake, and type of fault rupture (strike-slip, reverse, normal, or subduction). The published hazard evaluation of Petersen and others (1996) only considers uniform firm-rock site conditions. In this report, however, we extend the hazard analysis to include the hazard of exceeding peak horizontal ground acceleration (PGA) at 10% probability of exceedance in 50 years on spatially uniform conditions of rock, soft rock, and alluvium. These soil and rock conditions approximately correspond to site categories defined in Chapter 16 of the Uniform Building Code (ICBO, 1997), which are commonly found in California. We use the attenuation relations of Boore and others (1997), Campbell (1997), Sadigh and others (1997), and Youngs and others (1997) to calculate the ground motions.

The seismic hazard maps for ground shaking are produced by calculating the hazard at sites separated by about 5 km. Figures 3.1 through 3.3 show the hazard for PGA at 10% probability of exceedance in 50 years assuming the entire map area is firm rock, soft rock, or alluvial site conditions respectively. The sites where the hazard is calculated are represented as dots and ground motion contours as shaded regions. The quadrangle of interest is outlined by bold lines and centered on the map. Portions of the eight adjacent quadrangles are also shown so that the trends in the ground motion may be more apparent. We recommend estimating ground motion values by selecting the map that matches the actual site conditions, and interpolating from the calculated values of PGA rather than the contours, since the points are more accurate.

BALDWIN PARK 7.5 MINUTE QUADRANGLE AND PORTIONS OF ADJACENT QUADRANGLES

10% EXCEEDANCE IN 50 YEARS PEAK GROUND ACCELERATION (g)

1998
FIRM ROCK CONDITIONS
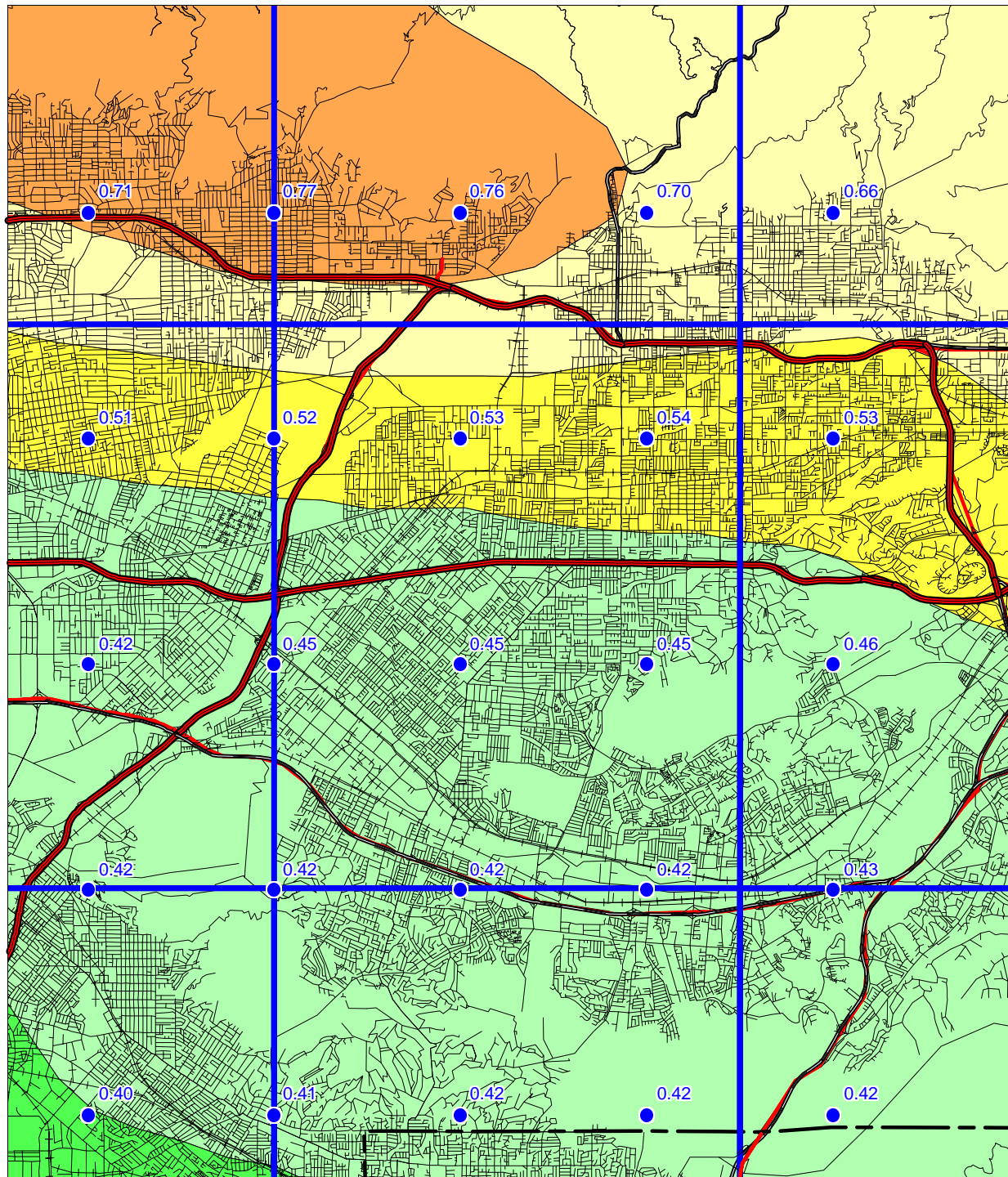
Base map modified from MapInfo StreetWorks ©1998 MapInfo Corporation

0   2.5   5
Kilometers

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Figure 3.1

BALDWIN PARK 7.5 MINUTE QUADRANGLE AND PORTIONS OF ADJACENT QUADRANGLES

10% EXCEEDANCE IN 50 YEARS PEAK GROUND ACCELERATION (g)

1998
SOFT ROCK CONDITIONS

Base map modified from MapInfo StreetWorks © 1998 MapInfo Corporation

0   2.5   5
Kilometers

Department of Conservation
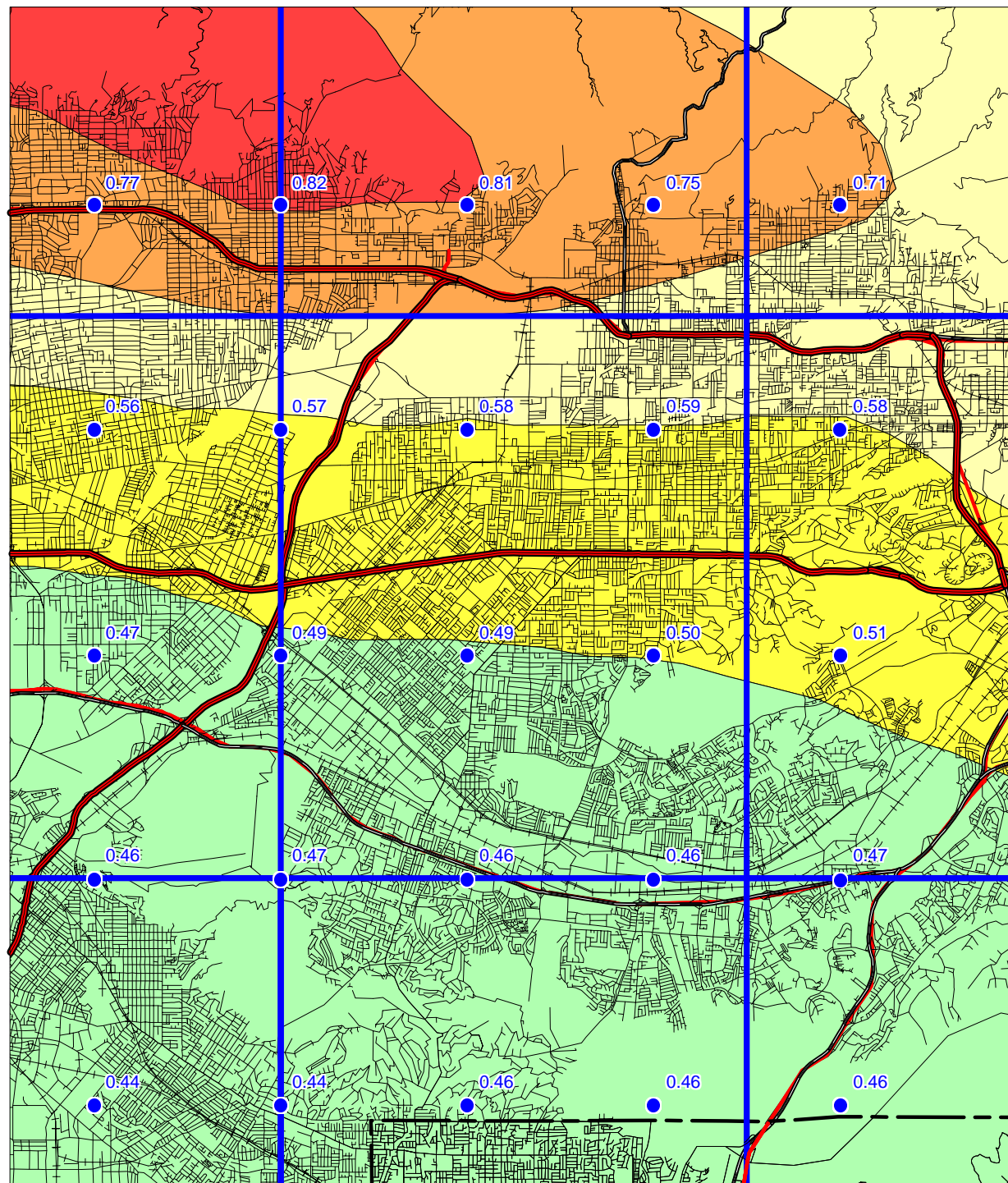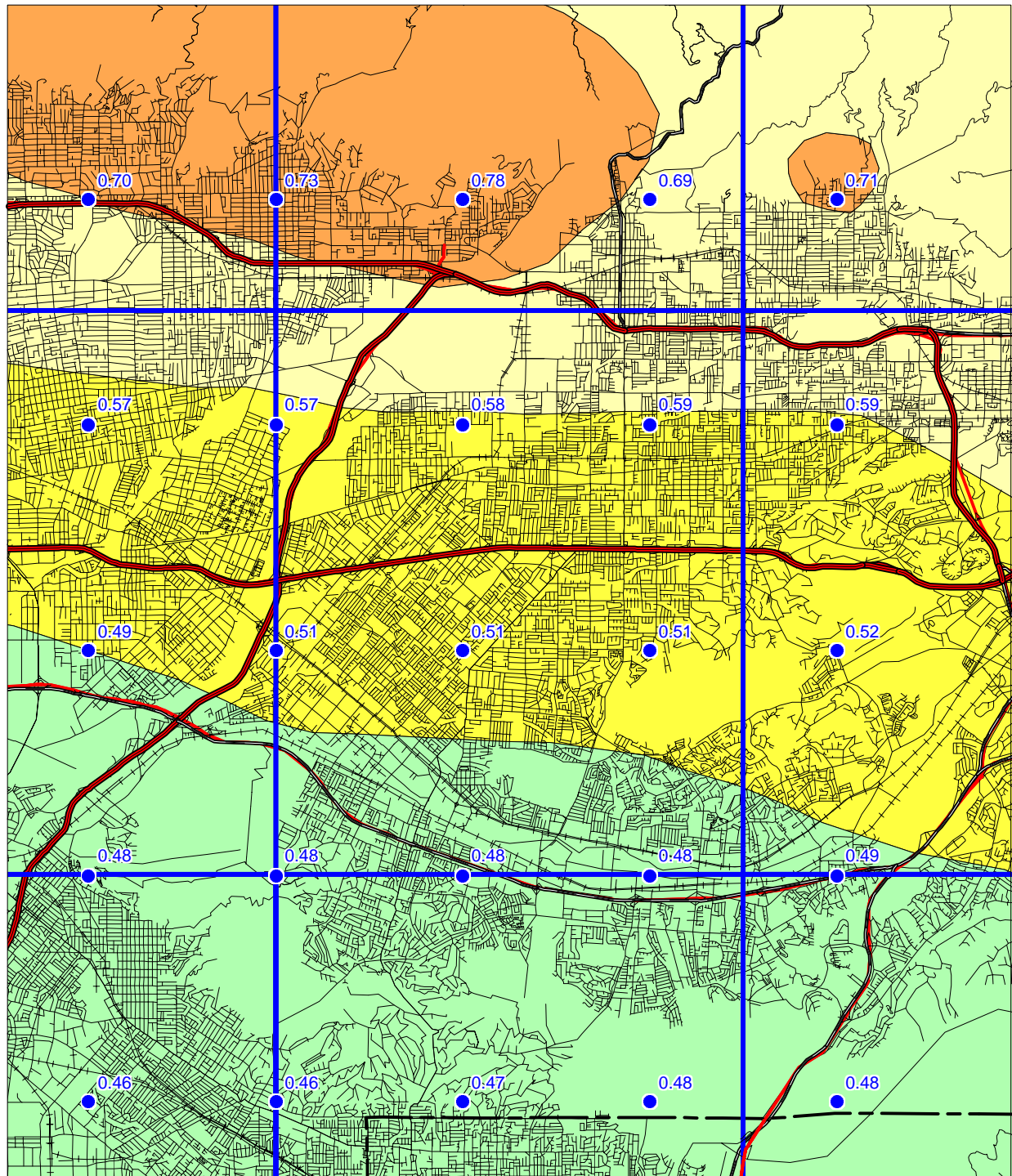Division of Mines and Geology

Figure 3.2

BALDWIN PARK 7.5 MINUTE QUADRANGLE AND PORTIONS OF ADJACENT QUADRANGLES

10% EXCEEDANCE IN 50 YEARS PEAK GROUND ACCELERATION (g)

1998

ALLUVIUM CONDITIONS

Base map modified from MapInfo Street Works ©1998 MapInfo Corporation

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Figure 3.3

APPLICATIONS FOR LIQUEFACTION AND LANDSLIDE HAZARD ASSESSMENTS

Deaggregation of the seismic hazard identifies the contribution of each of the earthquakes (various magnitudes and distances) in the model to the ground motion hazard for a particular exposure period (see Cramer and Petersen, 1996). The map in Figure 3.4 identifies the magnitude and the distance (value in parentheses) of the earthquake that contributes most to the hazard at 10% probability of exceedance in 50 years on alluvial site conditions (*predominant earthquake*). This information gives a rationale for selecting a seismic record or ground motion level in evaluating ground failure. However, it is important to keep in mind that more than one earthquake may contribute significantly to the hazard at a site, and those events can have markedly different magnitudes and distances. For liquefaction hazard the predominant earthquake magnitude from Figure 3.4 and PGA from Figure 3.3 (alluvium conditions) can be used with the Youd and Idriss (1997) approach to estimate cyclic stress ratio demand. For landslide hazard the predominant earthquake magnitude and distance can be used to select a seismic record that is consistent with the hazard for calculating the Newmark displacement (Wilson and Keefer, 1983). When selecting the predominant earthquake magnitude and distance, it is advisable to consider the range of values in the vicinity of the site and perform the ground failure analysis accordingly. This would yield a range in ground failure hazard from which recommendations appropriate to the specific project can be made. Grid values for predominant earthquake magnitude and distance should **not** be interpolated at the site location, because these parameters are not continuous functions.

USE AND LIMITATIONS

The statewide map of seismic hazard has been developed using regional information and is ***not appropriate for site specific structural design applications***. Use of the ground motion maps prepared at larger scale is limited to estimating earthquake loading conditions for preliminary assessment of ground failure at a specific location. We recommend consideration of site-specific analyses before deciding on the sole use of these maps for several reasons.

1. The seismogenic sources used to generate the peak ground accelerations were digitized from the 1:750,000-scale fault activity map of Jennings (1994). Uncertainties in fault location are estimated to be about 1 to 2 kilometers (Petersen and others, 1996). Therefore, differences in the location of calculated hazard values may also differ by a similar amount. At a specific location, however, the log-linear attenuation of ground motion with distance renders hazard estimates less sensitive to uncertainties in source location.

2. The hazard was calculated on a grid at sites separated by about 5 km (0.05 degrees). Therefore, the calculated hazard may be located a couple kilometers away from the site. We have provided shaded contours on the maps to indicate regional trends of the hazard model. However, the contours only show regional trends that may not be apparent from points on a single map. Differences of up to 2 km have been observed between contours and individual

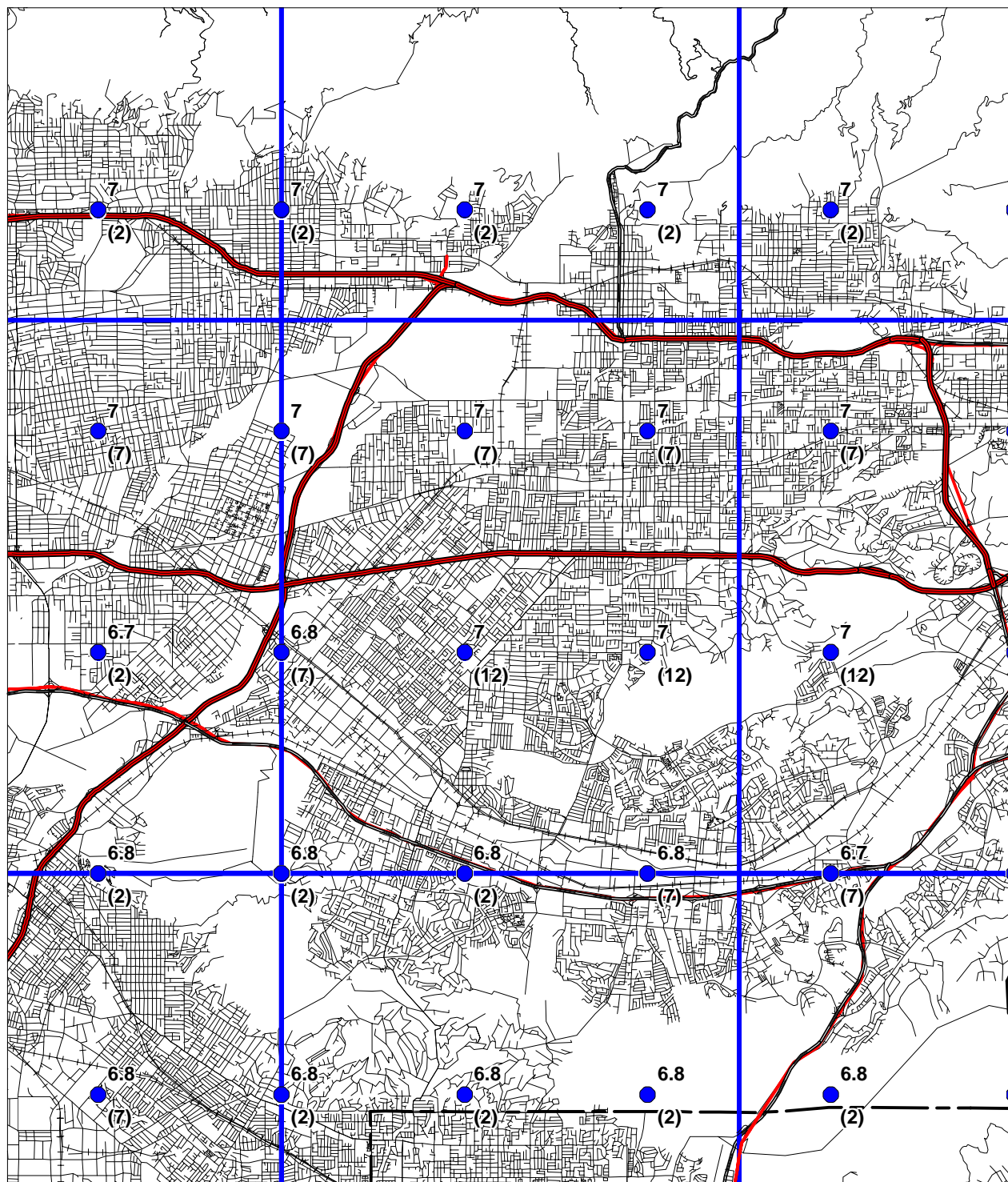BALDWIN PARK 7.5 MINUTE QUADRANGLE AND PORTIONS OF
ADJACENT QUADRANGLES
10% EXCEEDANCE IN 50 YEARS PEAK GROUND ACCELERATION

1998
PREDOMINANT EARTHQUAKE
Magnitude (Mw)
(Distance (km))

Base map modified from MapInfo StreetWorks ©1998 MapInfo Corporation

0   2.5   5

Kilometers

Department of Conservation
Division of Mines and Geology
Figure 3.4

ground acceleration values. We recommend that the user interpolate PGA between the grid point values rather than simply using the shaded contours.

3. Uncertainties in the hazard values have been estimated to be about +/- 50% of the ground motion value at two standard deviations (Cramer and others, 1996).

4. Not all active faults in California are included in this model. For example, faults that do not have documented slip rates are not included in the source model. Scientific research may identify active faults that have not previously been recognized. Therefore, future versions of the hazard model may include other faults and omit faults that are currently considered.

5. A map of the predominant earthquake magnitude and distance is provided from the deaggregation of the probabilistic seismic hazard model. However, it is important to recognize that a site may have more than one earthquake that contributes significantly to the hazard. Therefore, in some cases earthquakes other than the predominant earthquake should also be considered.
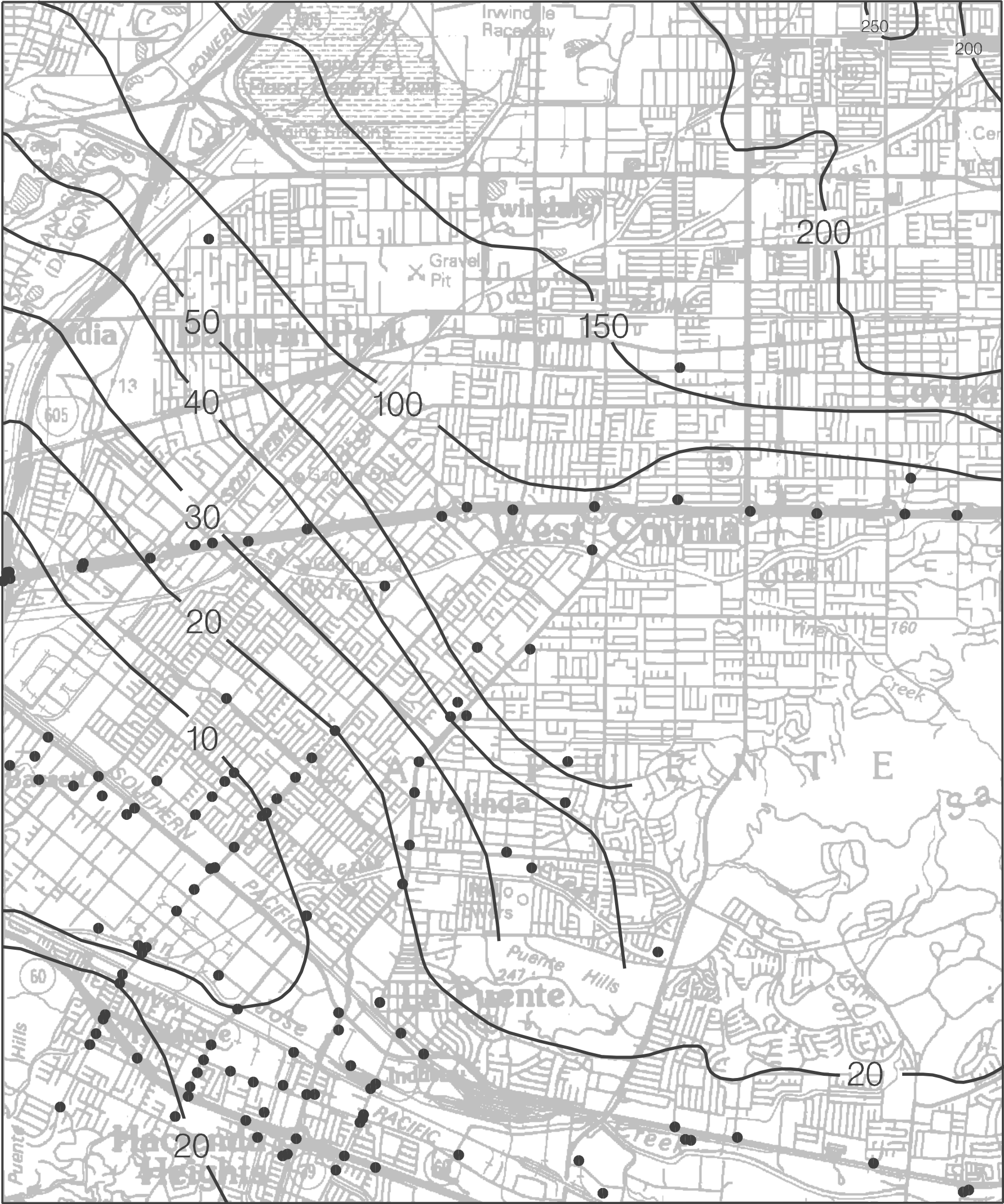
Because of its simplicity, it is likely that the SPPV method (California State Mining and Geology Board, 1997) will be widely used to estimate earthquake shaking loading conditions for the evaluation of ground failure hazards. It should be kept in mind that ground motions at a given distance from an earthquake will vary depending on site-specific characteristics such as geology, soil properties, and topography, which may not have been adequately accounted for in the regional hazard analysis. Although this variance is represented to some degree by the recorded ground motions that form the basis of the hazard model used to produce Figures 3.1, 3.2, and 3.3, extreme deviations can occur. More sophisticated methods that take into account other factors that may be present at the site (site amplification, basin effects, near source effects, etc.) should be employed as warranted. The decision to use the SPPV method with ground motions derived from Figures 3.1, 3.2, or 3.3 should be based on careful consideration of the above limitations, the geotechnical and seismological aspects of the project setting, and the "importance" or sensitivity of the proposed building with regard to occupant safety.

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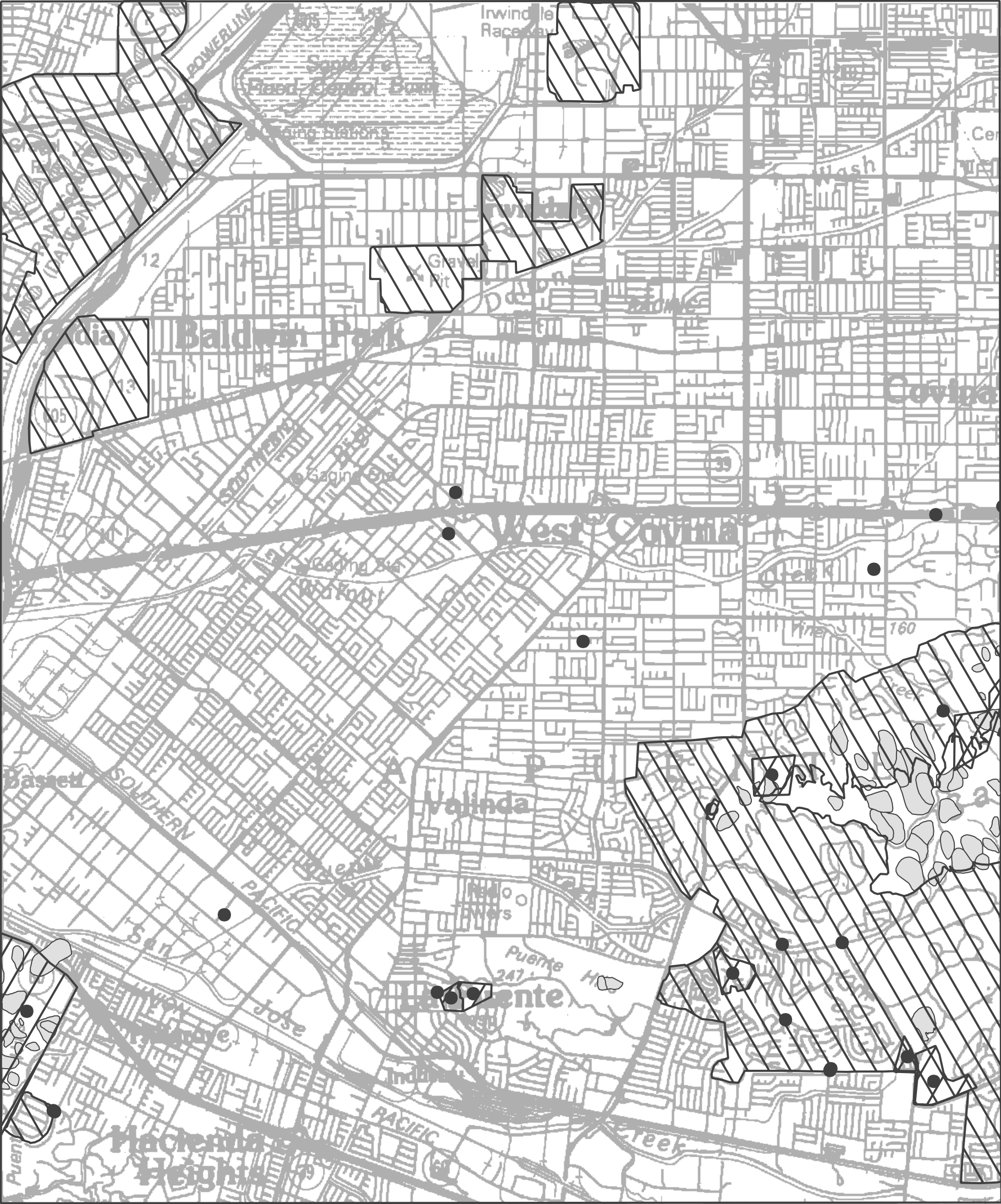
Base map enlarged from U.S.G.S. 30 x 60–minute series

Plate 1.1 Quaternary Geologic Map of the Baldwin Park Quadrangle.

See Geologic Conditions section in report for descriptions of the units.

B = Pre–Quaternary bedrock.

ONE MILE

SCALE

Plate 1.2 Historically Highest Ground Water Contours and Borehole Log Data Locations, Baldwin Park Quadrangle.

● Borehole Site   ⌒ 30 ⌒   Depth to ground water in feet

Base map enlarged from U.S.G.S. 30 x 60–minute series

ONE MILE

SCALE
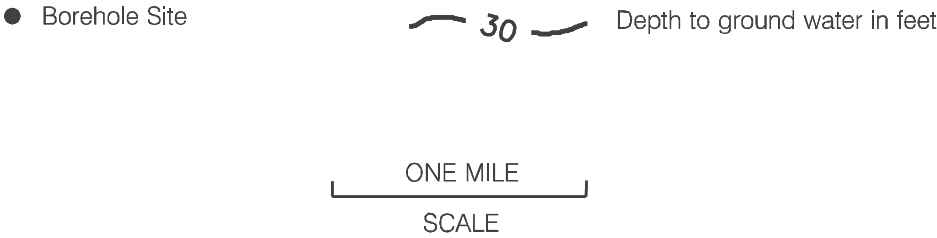
Base map enlarged from U.S.G.S. 30 x 60–minute series

Plate 2.1 Landslide inventory, data collection site and tract location map, Baldwin Park Quadrangle.

● Boring or sample location   ⬭ Landslide   Areas of significant grading   Tract report with multiple borings

ONE MILE

SCALE